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THE PEACH BORER

HOW TO PREVENT OR LESSEN ITS RAVAGES

The Para-dichlorobenzene Treatment

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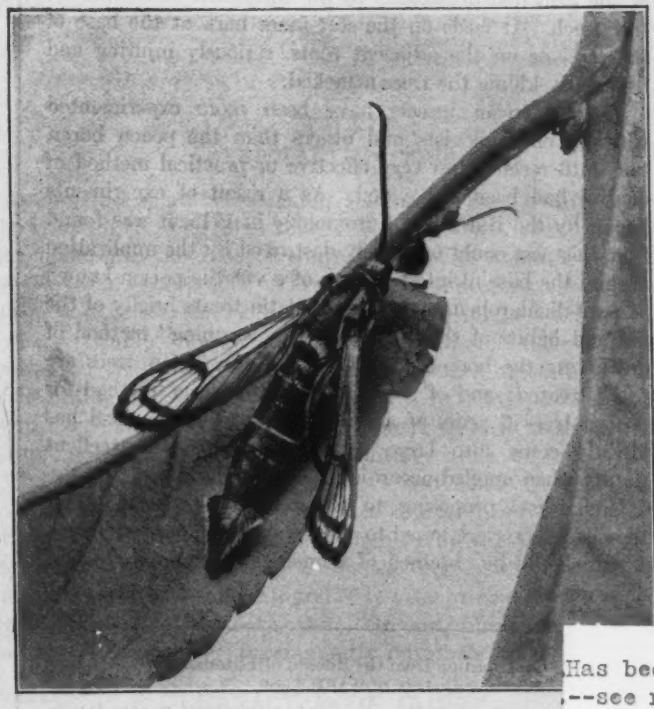

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FARMERS' BULLETIN 1246
UNITED STATES DEPARTMENT OF AGRICULTURE

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THE so-called peach borer, the larva of a beautiful clear-winged moth, has been for upward of 150 years one of the principal drawbacks to the successful cultivation of the peach. It feeds on the soft inner bark at the base of the tree, or on the adjacent roots, seriously injuring and frequently killing the trees attacked.

Few American insects have been more experimented with by entomologists and others than the peach borer, but until recently no very effective or practical method of control had been discovered. As a result of experiments begun by the Bureau of Entomology in 1915, it was found that this pest could be largely destroyed by the application around the base of infested trees of a volatile poison known as para-dichlorobenzene. This bulletin treats briefly of the life and habits of the insect; of the "worming" method of destroying the borers, suitable where only a few trees are to be treated; and of the para-dichlorobenzene method for use on trees 6 years of age and older. The chemical has already come into large commercial use with excellent results when applied according to directions.

Orchardists proposing to use para-dichlorobenzene for the peach borer are urged to employ only the pure chemical, which should be obtained of a fineness of granulated sugar or coarse salt.

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief.

Washington, D. C. October, 1921

THE PEACH BORER:[1] HOW TO PREVENT OR LESSEN ITS RAVAGES; THE PARA-DICHLOROBENZENE TREATMENT.

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A VERITABLE SCOURGE.

Among insect pests attacking the peach few, if any, are more important or more serious than the peach borer. Its injuries each year, including the cost of control measures, amount probably to not less than $6,000,000. Throughout much of its range of distribution east of the Rocky Mountains, from Canada south to Florida, it is a veritable scourge and must be combated relentlessly if the peach is to be grown. Trees of all ages, from those in the nursery to the oldest relic, are subject to attack. In many parts of the country the insect is so abundant that most trees in orchards become infested within a year or so after planting.

The peach borer is a native insect and has been complained of in horticultural and other literature almost from the time of the introduction of the peach in this country by the early settlers. Its original food plants were doubtless the wild cherry and wild plum, and on these it can still be found. It attacks also other stone fruits, such as nectarine, apricot, prune, almond, plum, and a few other plants. It is, however, preeminently injurious to the peach.

CHARACTER OF INJURY.

Injury is done by the larva, or borer, in the course of its feeding. Trees are injured principally at or somewhat below the ground level, and galleries or burrows are eaten in the soft bark or cambium at the crown of the trees or along the larger roots (fig. 1). Young trees may soon be more or less girdled (fig. 2) and older trees so injured that their vitality and crop-bearing capacity are greatly reduced.

[1] *Aegeria exitiosa* Say; order Lepidoptera, family Sesiidae.

Injured trees are, perhaps, more subject to infestation by certain diseases, such as root-rot, crown gall, and peach yellows, and are certainly less able to withstand periods of drought.

Infestation of trees by the borer is usually shown by an exudation, around the crown, of jellylike gum, more or less mixed with dirt and small brown pellets—the excrement, or frass, voided by the borers in the course of their growth (fig. 3). This exudation of gum is especially evident during moist or rainy weather.

FIG 1.—The peach borer in its galleries at the crown of the peach tree.

HOW THE INSECT DEVELOPS AND LIVES.

The peach borer, in the course of its life, goes through four distinct stages—the egg; the larva, or borer; the pupa; and the adult, or parent moth.

THE EGG.

The eggs of the peach borer are small and inconspicuous, reddish brown in color, oblong in shape, and measure about $\frac{1}{30}$ inch in length (fig. 4). They are deposited rather promiscuously over the trunk, limbs, and foliage of the peach tree, and many eggs are laid on weeds and trash or on the ground at or near the base of the trees. The eggs hatch in about 10 days, though this period may vary somewhat. The abundance and destructiveness of the peach borer is due, in considerable part, to the fact that the moths are very prolific. Observations on the number of eggs deposited by a given female show that she may lay as many as 829 eggs, with an average of about 400.

THE LARVA OR BORER.

When the egg has hatched, the little larva coming out of it makes its way as rapidly as possible to the collar of the tree, if not already at or near its base, and at once begins burrowing into the bark, entering often through a crack or wound. Some of the larvæ enter on the trunk, or even on the limbs, but these usually fail to survive long. After the larva has gained entrance to the soft bark of the tree it feeds greedily and grows rapidly, and in the course of a few weeks has become of sufficient size to do material damage.

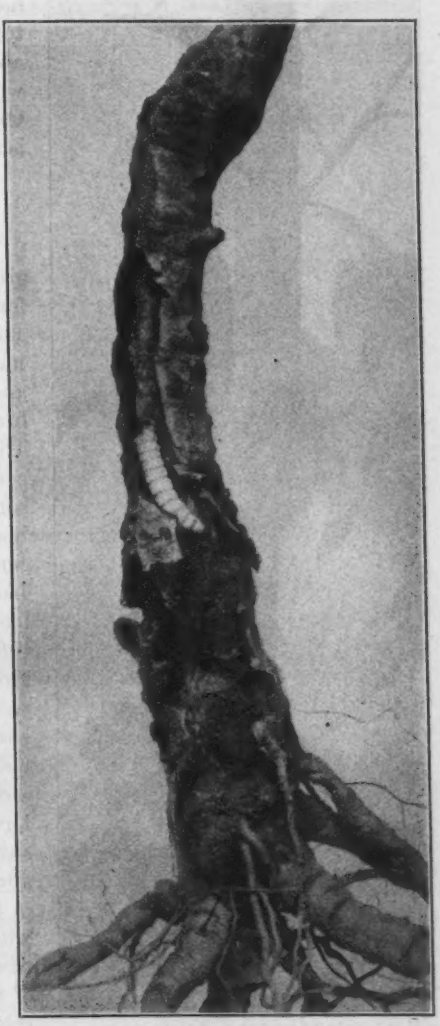

FIG. 2.—Young peach tree practically girdled by the peach borer.

The number of larvæ which may infest a single tree is often surprising, and it is a matter of wonder that trees so infested are not completely killed within a season. The average number of larvæ to a tree in orchards varies widely according to region, in some sections there being only 2 or 3, whereas in other regions some 8 or 10 borers are usually present. In extreme cases 40, 60, and even 90 borers have been found infesting the roots and crown of individual peach trees 6 or 7 years old.

There is only one generation a year. The larger borers pass the winter in their burrows in the bark, though many of the smaller ones construct a cell, or hibernaculum, outside of the burrow on the bark of the tree. Feeding is active from early spring until late fall and, in the South, also during warm

periods in the winter. Larvæ varying from quite small to nearly full grown are to be found in the trees during summer; during late spring, however, they are more nearly of full size. The mature peach borer (fig. 5) is about an inch long, yellowish-white, with dark reddish head. On the body are a few brownish hairs arising from tubercles.

FIG. 3.—Gum and frass exuding from base of peach tree, the usual sign of infestation.

THE PUPA.

The peach borer, when full grown and ready to change its form, incloses itself in a cocoon composed of silk, in which are incorporated particles of bark and excrement, forming a tough, brownish, capsule-like structure. The cocoon (fig. 6) is usually constructed at the head of or somewhat beyond the larval burrow, and, owing to its similarity in color to that of the bark of the tree, it is often overlooked by orchardists. Borers infesting the roots some inches from the base of the tree may work directly upward to the surface of the soil and there construct their cocoons. Sheltered within the cocoon the larva changes to a pupa, or chrysalis. The pupa (fig. 7) is about three-fourths of an inch in length, brown, and provided with stiff spines on the back to assist it in working itself out of the cocoon, thus facilitating the escape of the moth. Within three or four weeks the pupa is fully developed and wriggles out of the cocoon, the emerging moth leaving the empty skin protruding more than halfway from the cocoon (fig. 6).

THE MOTH.

The moths of the peach borer are beautiful clear-winged insects, the male differing strikingly from the female in markings. In the male (fig. 8) the wings are transparent, with steel-blue trimmings along the margin and veins, and the abdomen is marked with narrow yellow bands, quite conspicuous on the steel-blue ground color. The female (fig. 9) is steel-blue, with opaque forewings, and there are one or two orange-colored bands around the abdomen.

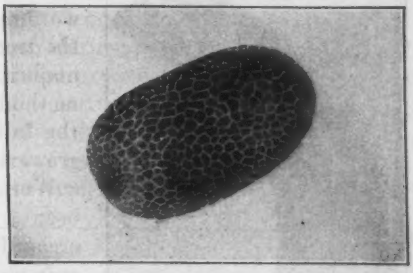

FIG. 4.—Egg of the peach borer moth. Considerably enlarged.

The adults are day fliers and, owing to their general resemblance to wasps when on the wing, are at times mistaken for these. Very soon after emergence mating takes place and oviposition begins. It is doubtful whether the moths feed to any extent during the course of their lives, and within a few days the eggs have been deposited and the moths have died.

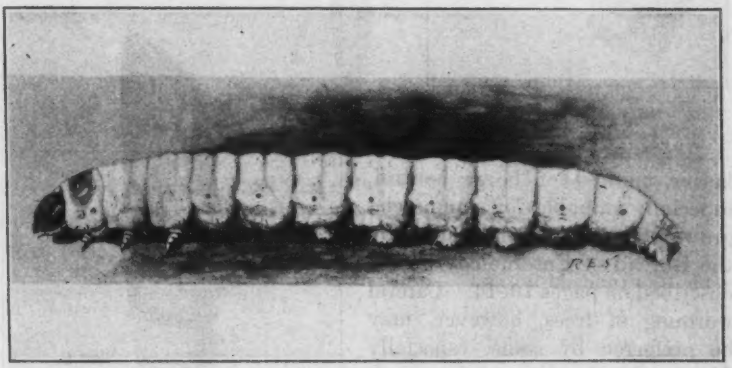

FIG. 5.—The peach borer. Enlarged.

HOW TO CONTROL THE PEST.

Many methods of control of the peach borer have been proposed during the more than 150 years that this pest has been known to injure the peach. Horticultural literature contains numerous accounts of the experience of growers with this or that wash or method of treatment of the borer, and entomologists, during the last 20 or 30 years, have given much time to discover, if possible, ways and means of preventing or reducing its injuries. While some of the washes and

procedures recommended undoubtedly have reduced infestation, they have not afforded the trees adequate protection. Commercial peach growers for the most part have depended upon "worming" the trees. A few use a wash on the trunk after worming, or mound the earth around the trees, or do both, but the great majority have followed no other method than worming the trees in the fall or spring, the more careful growers worming during both seasons.

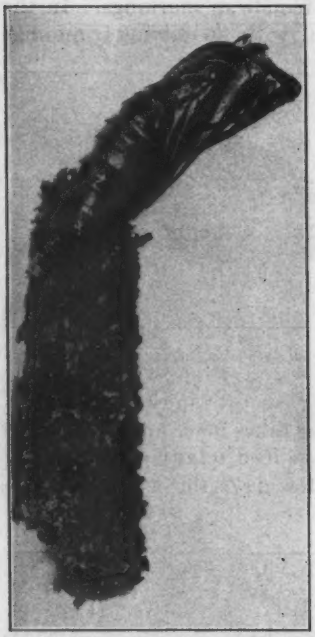

FIG. 6.—The peach borer cocoon and empty pupal skin. Enlarged.

Worming of peach trees has always been a bugbear to the commercial orchardist. It is a disagreeable and arduous task and likely to be slighted by the worker. Unless done conscientiously and thoroughly, with due care to remove all borers and not to injure the trees, worming is of questionable expediency. A decidedly better method of borer control, especially valuable for commercial growers, has been developed by the Bureau of Entomology and is described on pages 10–14. Careful worming of trees, however, may be preferred by some, especially where only a few trees are involved, as in small home orchards.

FIG. 7.—Pupa of the peach borer. Enlarged.

"WORMING."

Previous to worming, the earth should be removed from around the crown of the tree to a depth of 4 or 5 inches, and, if feasible, the trunk brushed or scraped to remove loose bark and dirt. With a little experience the worker can readily locate the borers in their burrows

and remove them by means of a knife or other suitable tool. In worming care should be taken not to cut the sound bark more than necessary, and the cutting should be done vertically. Carelessness in the use of worming tools may result in as much damage to trees as that caused by the insects. After trees have been wormed it is desirable, if practicable, to go over them again a few days later, when the location of any larvæ missed during the first examination will usually be indicated by the exuded excrement or frass. When the worming has been completed the earth should be replaced around the trees—in the fall, always before freezing weather sets in.

After spring worming, a wash can be applied, or the earth mounded somewhat around the base of the tree, or the wash and mound may

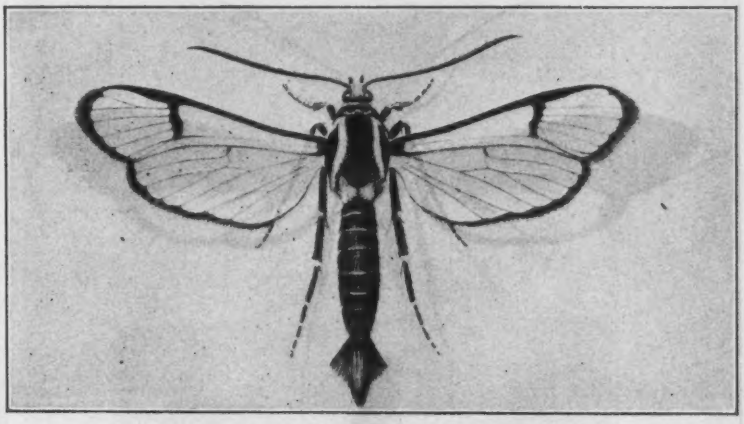

FIG. 8.—Adult male of the peach borer. Enlarged.

both be used (fig. 10). There is little if any advantage in the use of a wash, or in mounding, after the fall worming, since infestation occurs during the summer and early fall. The mounding will cause the borers to enter the bark somewhat higher, facilitating their detection and removal. If washes or wrappings are to be used they should be put on at once after the spring worming and before the earth is replaced around the trees. Perhaps as good a wash as any can be made from lime-sulphur concentrate (33° Baumé), used at the rate of 1 part to 6 or 7 parts of water, to which an amount of lime has been added to give it the consistency of heavy paint. A caustic wash can sometimes be used to advantage in the fall to destroy any little borers more or less exposed on the tree. For this purpose use caustic soda or lye at the rate of 1 pound to 8 or 9 gallons of water, and to this, after careful slaking, add about 10 pounds of stone lime.

THE PARA-DICHLOROBENZENE TREATMENT.

In 1915 the Bureau of Entomology began experiments in the use of various toxic gases as a possible means of control of the peach borer. This work, carried out by Mr. E. B. Blakeslee and continued for several seasons, covered a wide range of soil, climatic, and seasonal conditions, and demonstrated the usefulness for borer control of para-dichlorobenzene and the impracticability of using carbon disulphid, sodium cyanid, and certain other materials. Many experiments with para-dichlorobenzene showed that when properly used it is uniformly effective in killing a high percentage of the borers without injurious results to trees 6 years of age and

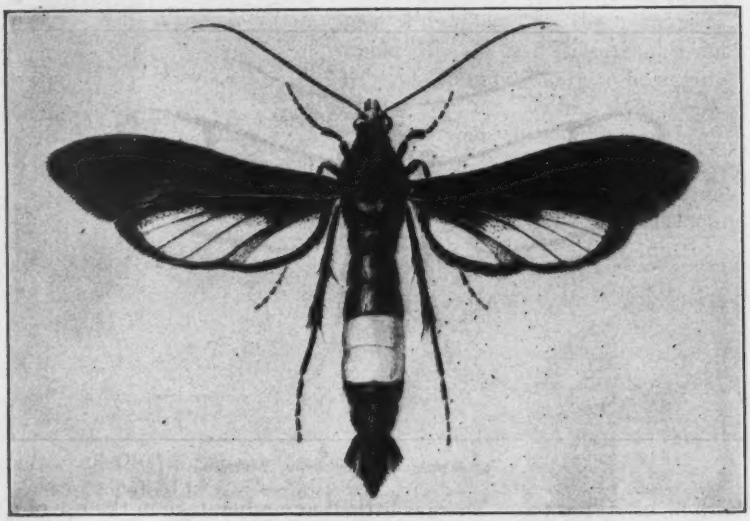

FIG. 9.—Adult female of the peach borer. Enlarged.

over. The results were published in United States Department of Agriculture Bulletin No. 796 (Oct. 21, 1919), and resulted in the prompt adoption of the treatment by many commercial peach growers. There has now been accumulated a sufficient body of experience, based on large-scale commercial use, and further experiments by the bureau and others, principally the New Jersey Agricultural Experiment Station, to show that a practical economic method of control has been found for this heretofore almost invulnerable pest.

PARA-DICHLOROBENZENE DESCRIBED.

Para-dichlorobenzene, for which the abbreviated name "paradichlor" is suggested when referred to as an insecticide, is a white crystalline substance having an etherlike odor, and vaporizing readily under

favorable conditions. The vapor, while harmless to persons and domestic animals under ordinary conditions, is poisonous to insects confined in its fumes for a sufficient length of time. Its vapor is heavier than air and readily permeates the soil. The chemical is, for practical purposes, noninflammable, and the fact that it is a finely divided solid adds much to the ease with which it may be applied. As usually sold it is a little too coarse for rapid volatilization, and orchardists in purchasing it should specify that they be furnished with a grade of the fineness of granulated sugar or coarse salt. Only the pure article should be purchased. Should there be some loss by evaporation in the containers the remainder of the chemical is

FIG. 10.—Peach tree to which a wash has been applied and earth mounded around the base.

always 100 per cent pure. If mixed with some inert material, the loss by evaporation of the "paradichlor" will result in a weakened mixture difficult to employ at a known strength.

WHEN TO APPLY IT.

The application of "paradichlor" to peach trees for the control of the peach borer should be made in the fall, after most of the moths have oviposited, to avoid late infestation of the trees. At this time many of the larvæ are still small and more or less exposed, and hence more susceptible to the gas than if deep in their burrows on the crown and roots. Applications must not be delayed, however, until the soil temperature is so low that proper volatilization of the chemical will not result. Many studies have been made as to the soil temperature

conditions best for the application of "paradichlor" and the following dates tentatively decided upon as best on the average for the respective regions:

Michigan, Ohio, Connecticut	September 1.
New Jersey, West Virginia, Maryland	September 10.
North Carolina and the Ozarks	September 25.
Georgia and Texas	October 10.

There are, however, limited seasonal variations in time of cessation of egg laying by moths in the fall. If applications of "paradichlor" are made as indicated, any belated young larvæ as they hatch will be killed for the most part during the continuance of the chemical around the trees—a period of several weeks—and beyond this time not much, if any, infestation will occur.

FIG. 11.—Preparation of ground previous to applying paradichlorobenzene and method of application of the chemical.

PREPARING THE TREES.

The earth for 15 or 18 inches around the base of trees should be cleaned of grass and weeds and leveled off, without, however, digging up the soil any more than necessary to break the surface crust (fig. 11). If borers are present in the trunk of the trees somewhat above the ground level, as indicated by the presence of gum or frass, a few shovelfuls of earth should be thrown around the tree and leveled off to form a bed for the application of the "paradichlor" high enough to subject the infested trunk to the fumes of the gas. As a rule the raising of the soil level around the tree will be unnecessary and is undesirable as favoring the washing down of the mounds by rain and interfering with the effectiveness of the treatment. If there is a decided mound of earth around the collar of the tree, this should be scraped down level with the surrounding soil. Excessive gum and frass should be removed and the bark lightly scraped. Exposed roots should be covered with a light layer of soil, since these are less resistant to gas fumes than the bark of the trees.

APPLYING THE "PARADICHLOR."

After the soil around the base of the tree has been prepared the "paradichlor" is applied evenly in a circular band an inch or two wide entirely around the tree, care being taken that the inner part of the band is about 2 inches from the tree trunk (fig. 11). Use 1 ounce per tree, by weight, or somewhat more for very large trees, and for convenience in measuring the chemical a small bottle or wooden or tin box holding just the desired amount may be employed. As soon as the chemical has been applied, cover it carefully with several shovelfuls of dirt, making a cone-shaped mound around the tree trunk by packing the earth with the back of the shovel (fig. 12).

FIG. 12.—Earth mounded around the base of peach tree to cover the para-dichlorobenzene.

IMPORTANT POINTS TO REMEMBER.

Under average fall weather conditions, with soil temperature around 60° F., or higher, most of the "paradichlor" under the soil covering will have evaporated in four to six weeks, killing from 90 to 100 per cent of the borers. Cooler weather than this, and frequent rains which keep the soil more or less wet, will greatly retard evaporation of the "paradichlor." Under these conditions, and in general practice if feasible, mounds should be removed some five to six weeks after application of the chemical, so as to avoid subjecting the tree further to the gas on account of danger of injury. From present knowledge, orchardists are taking undue risks, especially in case of applications later than above indicated, in allowing the mounds to remain around the trees over winter—a practice that has been frequently observed. Labor arrangements should be made to put on the chemical at the right time for its proper evaporation. In large commercial operations the work could well be divided into sections, with the necessary number of men in each section, under a competent foreman, to carry it along expeditiously. One group of men could prepare the trees for the "paradichlor," another group apply the chemical, and the third group follow immediately to cover and mound the trees.

DANGER OF INJURING TREES.

Most materials effective in killing insects will also injure trees when used in large dosages. In the successful use of insecticides it is necessary to ascertain the minimum amount which will kill the insect and which will not injure the plants treated. Para-dichlorobenzene is a good example of such a chemical where the margin of safety is adequate for its practical employment as an insecticide, but where care on the part of users must always be employed. Close adherence to the directions given, as to the time, method of application, and dosage, is urged upon the users of the "paradichlor" method of peach-borer control. In the experiments of the Bureau of Entomology when so used, no injury has been noted to trees 6 years of age and over, and its use on trees younger than this is not recommended.

How To Do It

DO YOU want practical suggestions on how to build a silo, a hog house, a poultry house, a potato-storage house, or how to make a fireless cooker, or other farm home convenience? Are you seeking ideas on how to prepare vegetables for the table, how to care for food in the home, how to bake bread and cake and other appetizing foods in an efficient and economical manner? Is there some practical question about your corn or wheat or cotton or other crops, or about your poultry or live stock, to which you are seeking an answer? The answers to thousands of such questions and practical suggestions for doing thousands of things about the farm and home are contained in over 500 Farmers' Bulletins, which can be obtained upon application to the Division of Publications, United States Department of Agriculture, Washington, D. C.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1246 rev. July 1932

THE PEACH BORER

HOW TO PREVENT OR LESSEN ITS RAVAGES

Rev. ed. follows

THE PEACH BORER, the larva of a beautiful clear-winged moth, has for more than a century and a half been one of the principal obstacles to successful culture of the peach. It feeds on the soft inner bark at the base of the tree, or on the adjacent roots, seriously injuring and frequently killing the tree. Since the Bureau of Entomology discovered in 1915 that the insect can almost certainly be destroyed by applying a volatile poison known as paradichlorobenzene around the bases of infested trees, peach growers have not feared the peach borer so much, although, unless control measures are used, it still causes very serious damage.

This bulletin treats briefly of the insect's life history and habits and the use of the paradichlorobenzene treatment on trees 4 years of age and older as well as on younger trees in localities where injury from the treatment does not appear to result. Mention is also made of destroying the borers by "worming," a method suitable for use on young trees or where only a few trees are to be treated.

Orchardists using paradichlorobenzene against the peach borer are advised to employ only the pure chemical, purchasing it in a form having about the fineness of granulated sugar, or in small, thin, flaky crystals.

Washington, D. C.

Issued October, 1921
Revised July, 1932

THE PEACH BORER[1]—HOW TO PREVENT OR LESSEN ITS RAVAGES; THE PARA-DICHLOROBENZENE TREATMENT

By A. L. QUAINTANCE, *Associate Chief, Bureau of Entomology*[2]
Revised by B. A. PORTER, *Entomologist*, and OLIVER I. SNAPP, *Entomologist, Division of Fruit and Shade Tree Insects*

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AMONG INSECT pests that attack the peach few, if any, are potentially more important or more serious than the peach borer. Throughout much of its range of distribution, east of the Rocky Mountains from Canada to Florida, it causes serious injury and the premature death of many trees wherever treatment is neglected. Fortunately, the paradichlorobenzene treatment outlined in this bulletin enables growers to deal very effectively with this insect.

The peach borer is a native of the United States and has been reported in horticultural and other literature almost from the time the early settlers introduced the peach into this country. Its original food plants were doubtless the wild cherry and wild plum, and on these it can still be found. It also attacks other stone fruits, such as nectarine, apricot, prune, almond, plum, and a few other closely related fruit trees. It is, however, preeminently injurious to the peach.

CHARACTER OF INJURY

The injury is done by the larva, or borer, which feeds in the trunk, principally at or somewhat below the ground level, and eats galleries or burrows in the soft bark or cambium at the crown of the trees or along the larger roots. (Fig. 1.) Young trees may soon be completely girdled (see title-page) or nearly so, and older trees so injured that their vitality and crop-bearing capacity are greatly reduced. Injured trees are particularly susceptible to attack by bark beetles, may be more subject to infection by certain diseases such as root rot, and are less able to withstand periods of drought.

[1] *Aegeria exitiosa* Say; order Lepidoptera, family Sesiidae.
[2] Resigned Dec. 31, 1930.

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Infestation by the borer is usually shown by an exudation of jelly-like gum around the crown, more or less mixed with dirt and brown pellets—the excrement, or frass, voided by the borers. (Fig. 2.) This exudation of gum is especially evident during damp or rainy weather.

FIGURE 1.—Peach borers in their galleries at the crown of a peach tree

HOW THE INSECT DEVELOPS AND LIVES

The peach borer, in the course of its life, goes through four distinct stages—the egg; the larva, or borer; the pupa; and the adult, or parent moth. There is only one generation a year. The eggs hatch in the fall, and the young borers at once attack the trees, passing the winter as partly grown larvae in their burrows. In the spring they resume their growth and mature and spin their cocoons at various times during summer. The moths emerge during the summer and fall, the exact time differing in different localities. Shortly after emerging the moths lay their eggs.

THE EGG

The eggs of the peach borer are small and inconspicuous, reddish brown, oblong, and measure about one-fiftieth inch in length. (Fig. 3.) Most of the eggs are deposited on the trunk of the tree near the base, although some are placed on the limbs and foliage of the peach tree, and a few are laid on weeds and trash or on the ground at or near the bases of the trees. Naturally many larvae fail to establish themselves on the trunks of the trees, but this loss is more than offset by the fact that the moths are very prolific. Observations have shown that a single female may lay more than 1,200 eggs and the average is probably between 400 and 600.

THE LARVA, OR BORER

The egg hatches in about 10 days, and the little larva coming out of it makes its way as rapidly as possible to the collar of the tree, if not already in that area, and at once begins burrowing into the bark, often entering through a crack or wound. Some of the larvae enter the trunk, or even the limbs, but these usually do not survive long. After the larva has gained entrance to the soft bark of the tree it feeds greedily and grows rapidly, and in a few weeks is sufficiently large to do material damage.

FIGURE 2.—Gum and frass exuding from base of a peach tree, the usual sign of infestation

The number of larvae which may infest a single tree is often surprising, and it is a matter of wonder that trees heavily infested are not completely killed within a season. The average number of larvae to a tree in orchards differs widely according to region. In some regions there are only 2 or 3, whereas in others 8 or 10 borers are usually present. In extreme cases 40, 60, and even 90 borers have been found infesting the roots and crown of individual peach trees 6 or 7 years old.

The hatching period extends over most of the summer and fall—from late June until October, or even later in the extreme South, although most of the hatching is concentrated in a period of a few weeks in midsummer in northern localities and in late summer or fall at southern points. Larvae of different sizes, however, ranging from quite small to nearly full grown may be found in the trees at any time during the summer and fall.

Most of the feeding occurs in the fall and spring, but in the South the borers also feed more or less during warm periods in the winter. The mature peach-borer larva (fig. 4) is about an inch long, yellowish white, with a dark reddish head. On its body are a few brownish hairs arising from tubercles.

THE PUPA

The peach borer, when full grown and ready to change its form, incloses itself in a cocoon of silk in which are incorporated particles of bark and excrement, forming a tough, brownish, capsulelike structure. The cocoon (fig. 5) is usually constructed at the entrance to the larval burrow or even a short distance outside it, and because it is similar in color to the bark of the tree it is often overlooked by orchardists. Borers infesting the roots some inches from the base of the tree may work directly upward to the surface of the soil and there construct their cocoons. Sheltered within the cocoon the larva changes to a pupa, or chrysalis. The pupa (fig. 6) is about three-fourths of an inch in length and brown. On its back are stiff spines that assist it in working itself out of the cocoon and thus facilitate the escape of the moth. Within three or four weeks the pupa is fully developed and wriggles out of the cocoon, the emerging moth leaving the empty skin protruding more than halfway from the cocoon. (Fig. 5.) In late summer large numbers of these empty pupal shells may often be found around the base of a heavily infested tree.

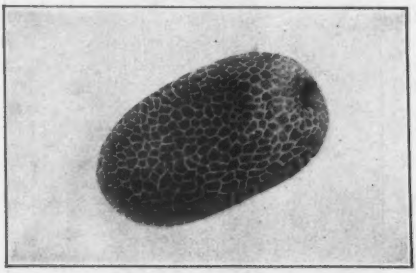

FIGURE 3.—Egg of the peach-borer moth. Enlarged sixty times

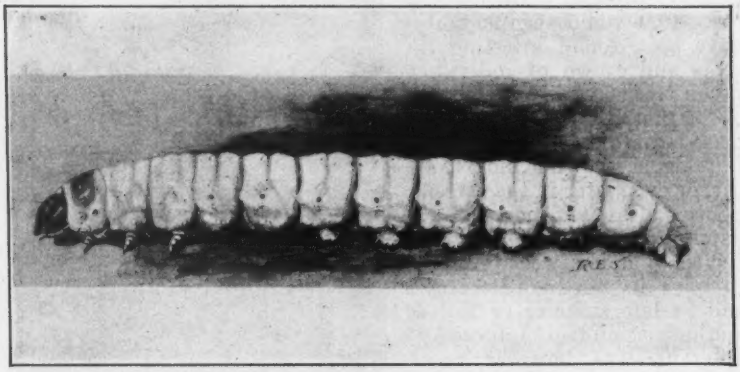

FIGURE 4.—The peach borer. Four times natural size

THE MOTH

The moths of the peach borer are beautiful clear-winged insects, the male differing strikingly from the female in markings. The wings of the male (fig. 7) are transparent, with steel-blue trimmings along the margin and veins, and its abdomen is marked with narrow yellow bands, quite conspicuous on the steel-blue ground color. The female (fig. 8) is steel blue, with opaque forewings, and has one or two orange-colored bands around the abdomen.

The adults are day fliers and, because of their general resemblance to wasps when on the wing, are sometimes mistaken for wasps. Mating takes place and oviposition begins very soon after emergence. It is doubtful whether the moths feed to any extent, and within a few days the eggs have been deposited, and the moths have died.

FIGURE 5.—The peach-borer cocoon and empty pupal skin. Three times natural size

HOW TO CONTROL THE PEST

THE PARADICHLOROBENZENE TREATMENT

In 1915 E. B. Blakeslee, of the Bureau of Entomology, began experiments in the use of various toxic gases as possible means of controlling the peach borer, and in the course of this work developed the paradichlorobenzene treatment. This treatment was promptly adopted by peach growers in many sections, and an extensive fund of experience with this material, based on large-scale commercial use, and on further experiments by the Bureau of Entomology and by numerous State agricultural experiment stations, has now been accumulated.

FIGURE 6.—Pupa of the peach borer. Enlarged four times

PARADICHLOROBENZENE DESCRIBED

Paradichlorobenzene, often referred to as "para" "PDB," or simply "gas," is a white crystalline substance having an etherlike odor and vaporizing readily under favorable conditions. The vapor, while harmless to persons and domestic animals under ordinary conditions, is poisonous to insects confined in its fumes for a sufficient length of time. It is heavier than air and readily permeates the soil. The chemical is, for practical purposes, noninflammable, and the fact that it is a finely divided solid adds much to the ease with which it may be applied. In purchasing paradichlorobenzene, or-

chardists should demand a grade having the fineness of granulated sugar or in small, thin, flaky crystals. Only the pure chemical should be purchased. Then, if there is some loss by evaporation in the containers the portion of the chemical that remains is always 100 per cent pure. If the chemical is mixed with some inert material, the loss by evaporation will be loss of the chemical only, and the strength of the remaining mixture will be unknown.

WHEN TO APPLY IT

Application of paradichlorobenzene to peach trees for the control of the peach borer is most effective in the fall, after most of the

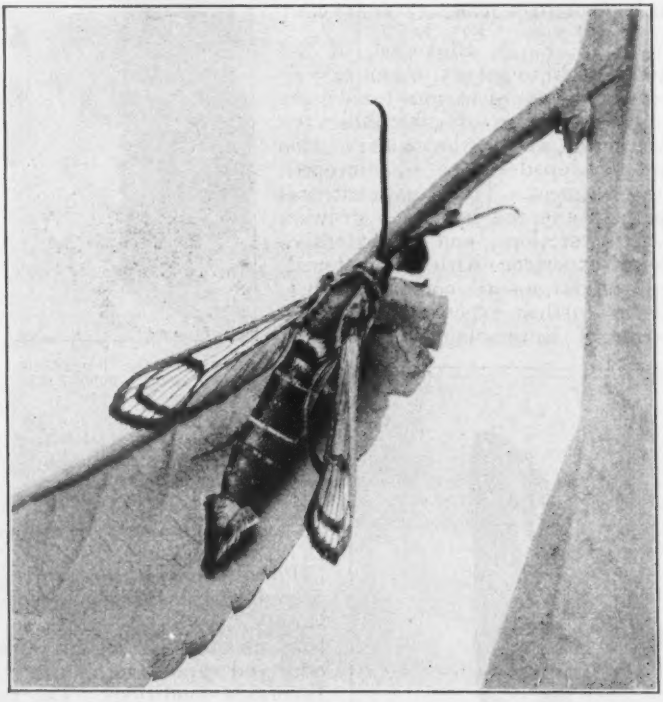

FIGURE 7.—Adult male of the peach borer resting on leaf. Enlarged four times

moths have oviposited. At this time many of the larvae are still small and more or less exposed, and hence are more susceptible to the gas than if they were deep in their burrows in the crown and roots. Applications must not be delayed, however, until the soil temperature is so low that the chemical will not volatilize properly. Many studies have been made on the soil temperatures best for the application of the chemical, and the following approximate dates have been tentatively decided upon as best, on the average, for different regions:

Michigan, New York, and New England States	Sept. 1–10
Southern Lake region, New Jersey, Pennsylvania	Sept. 15–25
Ozark region, Ohio Valley, Maryland, Virginia, Delaware	Sept. 20–30
Northern Georgia, the Carolinas, Tennessee	Sept. 25–Oct. 5
Central Georgia	Oct. 10–15
Southern Georgia	Oct. 15–20

If the paradichlorobenzene is applied within the dates indicated any late-hatching larvae will likely be killed by the gas which will continue to come from the chemical for a period of several weeks.

Fall applications are most effective, but if these have been neglected or were poorly timed, treatment sometimes becomes desirable in the spring. Spring applications of the chemical have given a fairly satisfactory kill, although the borers have by that time, of course, caused a great deal more damage than would have occurred

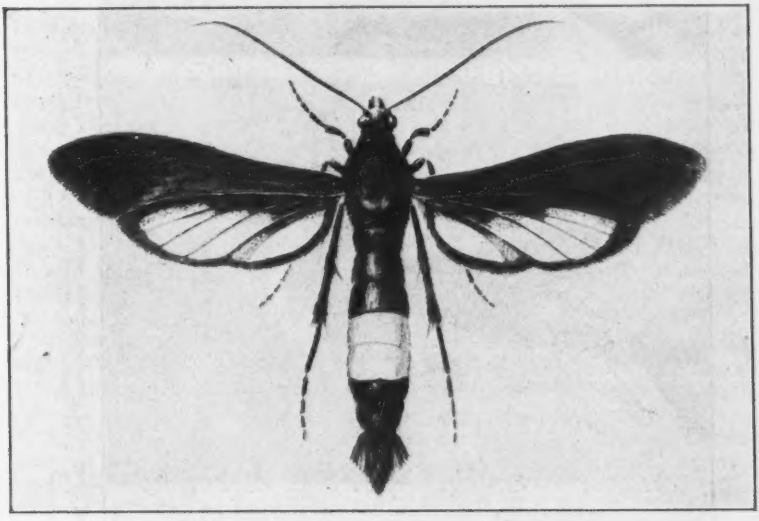

FIGURE 8.—Adult female of the peach borer. Four times natural size

if they had been killed in early fall while still small. Spring treatment should be given as soon as the ground begins to warm up, the exact time differing with the locality.

PREPARING THE TREES

The earth for 15 or 18 inches around the base of trees should be cleaned of grass and weeds and leveled off, without, however, digging up the soil any more than necessary to break the surface crust. (Fig. 9, A.) If borers are in the trunk somewhat above the ground level, as indicated by the presence of gum or frass, a few shovelfuls of earth should be thrown around the tree and leveled off to form a bed on which the chemical will rest above the infested part of the trunk, for this heavy gas sinks rather than rises through the

FIGURE 9.—Steps in the correct method of treating trees with paradichlorobenzene: A, The soil around this peach tree has been made ready for treatment; B, the ring of crystals should be from 1 to 1½ inches from the tree trunk; C, several shovelfuls of soil should be placed on top of the ring of crystals and packed lightly with the back of a shovel

soil. (Fig. 10, A.) As a rule, raising the soil level around the tree is unnecessary and is undesirable because the mound may be washed down by rain and the effectiveness of the treatment reduced. If there is a decided mound of earth around the collar of the tree, it should be scraped down level with the surrounding soil. Excessive gum and frass should be removed. Exposed roots should be covered with a light layer of soil, since they are less resistant to gas fumes than is the bark of the trees.

APPLYING THE CHEMICAL

After the soil has been prepared, the chemical is applied evenly in a band an inch or so wide entirely around the tree, care being taken that the inner part of the band is an inch to an inch and a half from the trunk. (Fig. 9, B.) The crystals should not be placed in contact with the tree (fig. 10, B), since they may injure it, nor should they be placed too far from the tree (fig. 10, C), in which case not enough gas will reach the tree trunk to be effective. For mature trees of average size 1 ounce, by weight, should be used; for unusually large trees an ounce and a half is sometimes needed; for trees 4 to 5 years old three-fourths of an ounce; and for trees 1 to 3 years of age one-half ounce, or slightly less, should be used. If many trees are to be treated, a container holding exactly the required amount of paradichlorobenzene is a great convenience. A small metal cup holding an ounce is often furnished with the chemical by insecticide dealers. As soon as the paradichlorobenzene has been applied, it should be covered with several shovelfuls of dirt, and the dirt packed with the back of the shovel (fig. 9, C) to make a cone-shaped mound.

Labor arrangements should be made to apply the chemical at the right time for its proper evaporation. In large commercial operations the work can well be divided among sections, with enough men in each section, under a competent foreman, to carry it along expeditiously. One group can prepare the trees for the paradichlorobenzene, another group can apply the chemical, and the third group can follow immediately to cover the crystals and mound the trees.

In late spring or early summer it is well to level off the mounds remaining from the previous season's treatment. This permits the new generation of borers to enter the tree at the normal location on the trunk, and facilitates the subsequent application of paradichlorobenzene.

Under normal temperatures the chemical applied at the recommended dates usually evaporates in four to six weeks. If unusually low temperatures prevail, or if frequent rains keep the soil wet, the evaporation of the chemical may be considerably retarded. Under such conditions, especially on younger trees, it is sometimes desirable to tear down the mounds after from four to six weeks in order to prevent the injury which might result from a prolonged exposure to the fumes of the chemical.

If the mounds are torn down in late fall, just before winter sets in, fresh earth should be placed around the tree to prevent winter injury in event of a sudden drop in temperature.

XUM

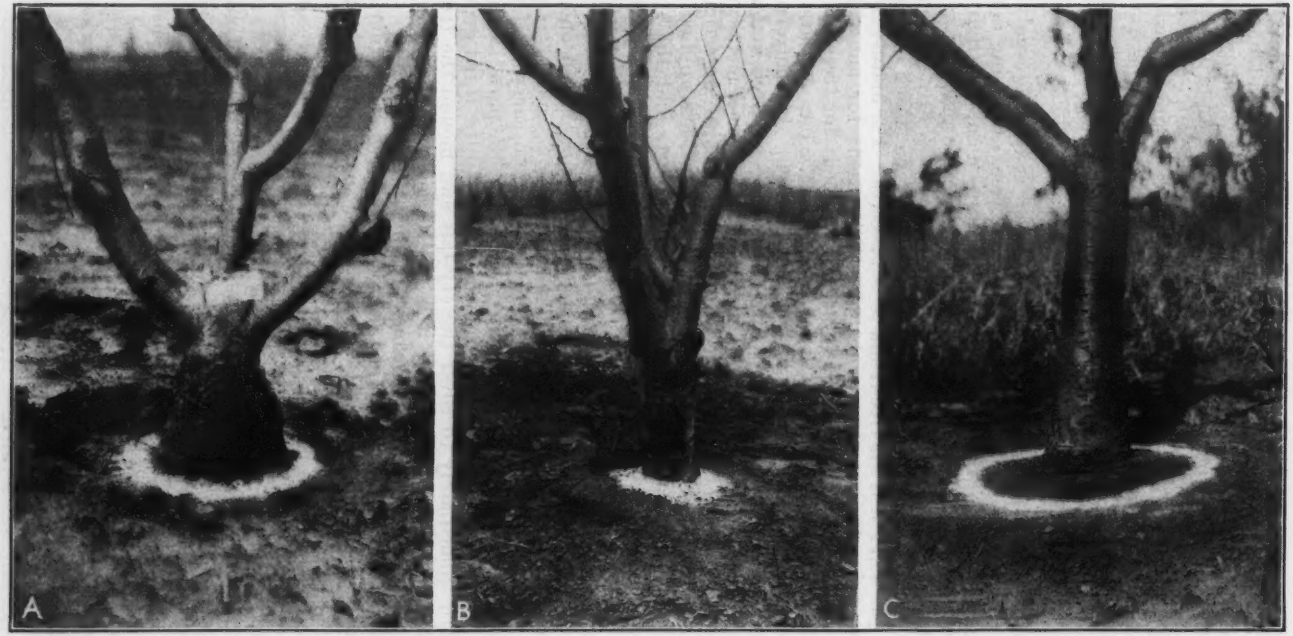

FIGURE 10.—Wrong ways of applying paradichlorobenzene: A, The paradichlorobenzene should be placed at a point above the topmost borer gallery; a mound should have been placed around this tree to a point above where the borers are working, so that the crystals could be placed above them as shown in Figure 9, B; B, if the chemical is placed against the tree trunk, severe injury may result; C, here the crystal ring is too far from the tree trunk to give effective results

INJURY

Under certain conditions paradichlorobenzene may cause injury to peach trees. This injury first becomes evident as brown flecks in the bark layers, which may continue into the cambium. In cases of severe injury these flecks converge into spots, forming a continuous layer of sour, brown tissue, which finally dies. If the injury extends all the way around the trunk, it will be fatal to the tree.

In the work of the Bureau of Entomology, the paradichlorobenzene treatment has caused no injury to trees 6 years of age or older. In a few instances slight injury has occurred to trees 4 and 5 years of age, but it has rarely proved serious. On trees 1, 2, and 3 years old, the use of paradichlorobenzene has resulted in injury in some localities, particularly in Georgia and New Jersey. In a few cases the injury has been severe enough to kill the trees. In experiments in the Middle West, on the other hand, only slight traces of injury have been detected in orchard trees of any age, and in no case has this injury been so severe as the injury caused by borers in untreated trees. The commercial peach growers of the Middle West have treated hundreds of thousands of young orchard trees without injury of any consequence. In deciding whether to treat young trees, growers should therefore be guided by the experience of other growers in their own sections. The paradichlorobenzene treatment has been found quite injurious to peach trees in the nursery and is therefore not recommended for such trees.

WORMING

Before the development of the chemical method of combating the peach borer, growers relied for control chiefly upon digging the borers out by hand. This method is still very useful for the control of the borer in young trees in regions in which paradichlorobenzene is likely to cause injury and also for small plantings or single backyard trees, where it is inconvenient to obtain a supply of the chemical.

Worming peach trees is a disagreeable and arduous task, and is likely to be slighted by the average worker. Unless done conscientiously and thoroughly, with proper care to remove all borers and to avoid unnecessary injury to the trees, worming is only partially effective and of questionable expediency.

In preparation for worming, the earth should be removed from around the crown of the tree to a depth of 4 or 5 inches, and if feasible the trunk should be brushed or scraped to remove loose bark and dirt. With a little experience the worker can readily locate the borers in their burrows and remove them with a knife or other suitable tool. In worming, care should be taken not to cut the sound bark more than necessary, and the cutting should be done vertically. Carelessness in the use of worming tools may result in as much damage to trees as that caused by the insects. After trees have been wormed it is desirable, if practicable, to go over them again a few days later, when the location of any larvae missed during

the first examination will usually be indicated by the exuded excrement or frass. When the worming has been completed the earth should be replaced around the trees, especially before freezing weather sets in.

If worming is to be done, it is helpful to mound the trees somewhat during the early summer. This causes the newly hatched borers to attack the tree a little higher than would otherwise be the case, and the task of removing them by hand is somewhat simplified.

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FARMERS' BULLETIN No. 1246 Rev. Jan. 1940

THE PEACH BORER

HOW TO PREVENT OR LESSEN ITS RAVAGES

Rev. ed. follows

FOR MORE than a century and a half the peach borer, the larva of a beautiful clear-winged moth, has been one of the principal obstacles to successful culture of the peach. It feeds on the soft inner bark at the base of the tree or on the adjacent roots, seriously injurying and frequently killing the tree. This bulletin treats briefly of the insects's life history and habits and discusses the following three methods of control: (1) The application of paradichlorobenzene, which has been successfully used for more than 20 years on older trees, although often causing damage to trees 3 years of age or younger; (2) the more recently developed ethylene dichloride treatment, which is more effective than the use of paradichlorobenzene in cool weather and much less likely to cause injury to younger trees; and (3) the old-time practice of "worming," a method suitable for the destruction of borers if only a few trees are to be treated or if it is inconvenient to obtain a supply of suitable chemicals.

Washington, D. C.

Issued October 1921
Revised January 1940

THE PEACH BORER—HOW TO PREVENT OR LESSEN ITS RAVAGES

By OLIVER I. SNAPP, *entomologist, Division of Fruit Insect Investigations, Bureau of Entomology and Plant Quarantine*[1]

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AMONG INSECT PESTS that attack the peach few, if any, are potentially more injurious than the peach borer (*Conopia exitiosa* (Say)).[2] Throughout much of its range of distribution, east of the Rocky Mountains from Canada to Florida, and in certain restricted areas farther west, it causes serious injury and the premature death of many trees wherever treatment is neglected.

The peach borer is a native of the United States and has been reported in horticultural and other literature almost from the time the early settlers introduced the peach into this country. Its original food plants were doubtless the wild cherries and wild plums, and on these it can still be found. It also attacks other stone fruits, such as nectarine, apricot, prune, almond, plum, and a few other closely related fruit trees. It is, however, preeminently injurious to the peach.

CHARACTER OF INJURY

The injury is done by the larva, or borer, which feeds in the trunk principally at or somewhat below the ground level and eats galleries or burrows in the soft bark or cambium at the crown of the trees or along the larger roots (fig. 1). Young trees may soon be completely girdled (see title page), or nearly so, and older trees so injured that their vitality and crop-bearing capacity are greatly reduced. Injured trees are particularly susceptible to attack by bark beetles and are less able to withstand periods of drought.

Infestation by the borer is usually shown by an exudation of jellylike gum around the crown, more or less mixed with dirt and brown

[1] When first published, in October 1921, this bulletin was under the authorship of A. L. Quaintance, Associate Chief of the then Bureau of Entomology (resigned December 31, 1930); later, in July 1932, it was revised, still under Dr. Quaintance's authorship, by B. A. Porter and Oliver I. Snapp.

[2] Order Lepidoptera, family Aegeriidae.

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pellets—the excrement, or frass, voided by the borers (fig. 2). This exudation of gum is especially evident during damp or rainy weather.

HOW THE INSECT DEVELOPS AND LIVES

In the course of its life the peach borer goes through four distinct stages—the egg; the larva, or borer; the pupa; and the adult, or parent moth. There is only one generation a year. The eggs hatch in the summer and fall, and the young borers at once attack the trees, passing the winter as partly grown larvae in their burrows. In the spring they resume their growth and mature and spin their cocoons at various times during the summer. The moths emerge during the summer and fall, the exact period differing in different localities. Shortly after emerging the moths lay their eggs.

FIGURE 1.—Peach borers in their galleries at the crown of a peach tree.

THE EGG

The eggs of the peach borer are small and inconspicuous, reddish brown, oblong, and measure about one-fiftieth of an inch in length (fig. 3). Most of the eggs are deposited on the trunk of the tree near the base, although some are placed on the limbs and foliage of the peach tree and a few are laid on weeds and trash or on the ground at or near the bases of the trees. Naturally many larvae fail to establish themselves on the trunks of the trees, but this loss is more than offset by the fact that the moths are very prolific. Observations have shown that a single female may lay more than 1,200 eggs, and the average is probably between 500 and 600.

THE LARVA, OR BORER

The egg hatches in about 10 days, and the little larva coming out of it makes its way as rapidly as possible to the collar of the tree, if

not already in that area, and at once begins burrowing into the bark, often entering through a crack or wound. After the larva has gained entrance to the soft bark of the tree it feeds greedily and grows rapidly, and in a few weeks is sufficiently large to do material damage.

The number of larvae which may infest a single tree is often surprising, and it is a matter of wonder that trees heavily infested are not completely killed within a season. The average number of larvae to a tree in orchards differs widely according to the region. In some regions there are only 2 or 3, whereas in others 8 or 10 borers are usually present. In extreme cases 40, 60, and even 90 borers have been found infesting the roots and crowns of individual peach trees 6 or 7 years old.

The hatching period extends over most of the summer and fall—from late June until October, or even later in the extreme South, although most of the hatching is concentrated in a period of a few weeks in midsummer in northern localities and in late summer or fall at southern points. Larvae of different sizes, however, ranging from small to nearly full-grown may be found in the trees at any time during the summer and fall.

Most of the feeding occurs in the fall and spring, but in the South the borers also feed more or less during warm periods in the winter. The mature peach borer larva (fig. 4) is about an inch long and yellowish white and has a dark reddish head.

FIGURE 2.—Gum and frass exuding from base of a peach tree, the usual sign of infestation.

THE PUPA

The peach borer, when full-grown and ready to change its form, incloses itself in a cocoon of silk in which are incorporated particles

of bark and excrement, forming a tough, brownish, capsulelike structure. The cocoon (fig. 5) is usually constructed at the entrance to the larval burrow or even a short distance outside it and, because it is similar in color to the bark of the tree, is often overlooked by orchardists. Borers infesting the roots some inches from the base of the tree may work directly upward to the surface of the soil and there construct their cocoons. Sheltered within the cocoon, the larva changes to a pupa, or chrysalis. The pupa (fig. 6) is about three-fourths of an inch long and is brown. On its back are stiff spines that assist it in working itself out of the cocoon and thus facilitate the escape of the moth. Within 3 or 4 weeks the pupa is fully developed and wriggles out. The emerging moth leaves the empty skin protruding more than halfway from the cocoon (fig. 5). Late in the summer large numbers of these empty pupal shells may often be found around the base of a heavily infested tree.

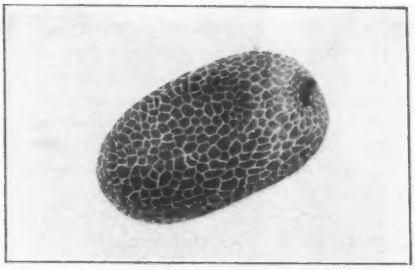
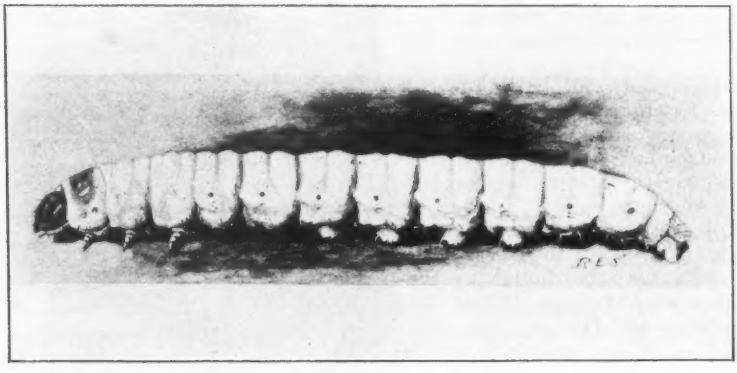


FIGURE 3.—Egg of the peach-borer moth. Sixty times natural size.



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The adults are day fliers and when on the wing are sometimes mistaken for wasps. Egg laying begins very soon after emergence. It

is doubtful whether the moths feed to any extent, and within a few days the eggs have been deposited, and the moths have died.

HOW TO CONTROL THE PEST

Two very effective insecticides are now available for peach borer control. The first of these, paradichlorobenzene, has been in use for more than 20 years. It is very effective in controlling the borers, but in some localities it is injurious to the younger trees. The second chemical, ethylene dichloride, has been under experiment at the Fort Valley, Ga., laboratory of the Bureau for the last 7 years. It has also been tested extensively in Illinois and New York in cooperation with State workers and has been used by a considerable number of commercial growers in the eastern half of the United States. This treatment has the advantage of being comparatively safe on young trees when applied at the proper strength; it can be used in colder weather than paradichlorobenzene; and it can be applied with greater ease.

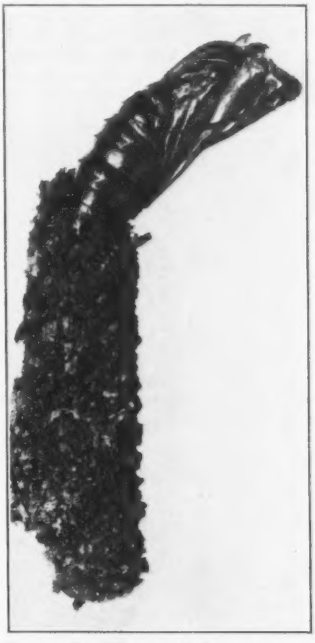

FIGURE 5.—The peach borer cocoon and empty pupal skin. Three times natural size.

THE PARADICHLOROBENZENE TREATMENT

Paradichlorobenzene, often referred to as "para" or "PDB", is a white crystalline substance having an etherlike odor and vaporizing readily under favorable conditions. The vapor, while harmless to persons and domestic animals under ordinary conditions, is poisonous to insects confined in its fumes for a sufficient length of time. It is heavier than air and readily permeates the soil. The chemical is, for practical purposes, noninflammable. In purchasing paradichlorobenzene orchardists should demand a grade having the fineness of granulated sugar or one coming in small, thin, flaky crystals. Only the pure chemical should be purchased. Then, if there is some loss by evaporation in the containers, the portion of the chemical that remains is always 100 percent pure. If the chemical is mixed with some inert material the loss by evaporation will be loss of the chemical only, and the strength of the remaining mixture will be unknown.

WHEN TO APPLY IT

Application of paradichlorobenzene to peach trees for the control of the peach borer is most effective in the fall, after most of the moths have laid their eggs. At this time many of the larvae are still small and more or less exposed, and hence are more susceptible to the

gas than if they were deep in their burrows in the crown and roots. Applications must not be delayed, however, until the soil temperature is so low that the chemical will not volatilize properly. Exact information on the best time for treatment in various localities should be obtained from the reader's State agricultural experiment station, extension service, or local authorities. The best approximate dates for certain regions are, however, as follows:

Michigan, New York, and New England States	Aug. 25–Sept. 10.
Southern Lake region, New Jersey, Pennsylvania	Sept. 15–25.
Ozark region, Ohio Valley, Maryland, Virginia, Delaware	Sept. 25–Oct. 5.
Northern Georgia, the Carolinas, Tennessee	Oct. 5–15.
Central Georgia	Oct. 20–25.
Southern Georgia	Oct. 25–30.

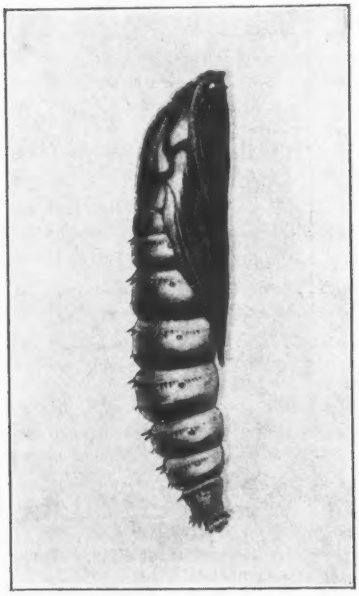

FIGURE 6.—Pupa of the peach borer. Four times natural size.

Fall applications are most effective, but if these have been neglected or were poorly timed, treatment sometimes becomes desirable in the spring. Spring applications of the chemical have given a fairly satisfactory kill, although by that time the borers have of course caused much more damage than would have occurred if they had been killed early in the fall while still small. Spring treatment should be given as soon as the ground begins to warm, the exact time differing with the locality.

PREPARING THE TREES

The earth for 15 or 18 inches around the base of trees should be cleaned of grass and weeds and leveled off, without, however, digging up the soil any more than necessary to break the surface crust (fig. 9, *A*). If borers are in the trunk somewhat above the ground level, as indicated by the presence of gum or frass, a few shovelfuls of earth should be thrown around the tree and leveled off to form a bed on which the chemical will rest above the infested part of the trunk, for this heavy gas sinks rather than rises through the soil. As a rule, raising the soil level around the tree is unnecessary and is undesirable because the mound may be washed down by rain and the effectiveness of the treatment reduced. Excessive gum and frass should be removed. Exposed roots should be covered with a light layer of soil, since they are less resistant to gas fumes than is the bark of the trees.

APPLYING THE CHEMICAL

After the soil has been prepared, the chemical is applied evenly in a band an inch or so wide entirely around the tree, care being taken that the inner part of the band is an inch to an inch and a half from the trunk (fig. 9, *B*). The crystals should not be placed in contact with the tree, since they may injure it, nor should they be placed too far from the tree, in which case not enough gas will reach the tree trunk to be effective. For mature trees of average size 1 ounce, by weight, should be used; for unusually large trees an ounce and a half or more is sometimes needed; for trees 4 to 5 years old, three-

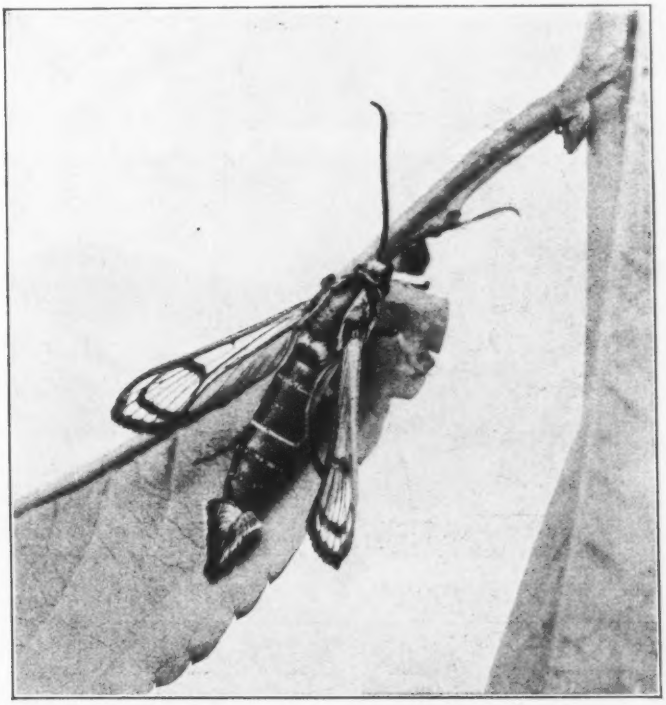

FIGURE 7.—Adult male of the peach borer resting on leaf. Four times natural size.

fourths of an ounce; and if trees 1 to 3 years of age are to be treated, one-fourth to one-half ounce should be used. If many trees are involved, a container holding exactly the required amount of paradichlorobenzene is a great convenience. A small metal cup holding an ounce is often furnished with the chemical by insecticide dealers. As soon as the paradichlorobenzene has been applied, it should be covered with several shovelfuls of dirt, care being taken not to disturb

the ring of crystals, and the dirt packed with the back of the shovel (fig. 9, *C*) to make a low cone-shaped mound.

Under normal temperatures the chemical applied at the recommended dates usually evaporates in 4 to 6 weeks. If unusually low temperatures prevail or if frequent rains keep the soil wet, the evaporation of the chemical may be considerably retarded. Under such conditions, especially on trees less than 6 years of age, it is sometimes desirable to tear down the mounds after from 4 to 6 weeks to prevent the injury which might result from a prolonged exposure to the fumes of the chemical.

If the mounds are torn down late in the fall, just before winter sets in, fresh earth should be placed around the tree to prevent winter injury in event of a sudden drop in temperature.

Late in the spring or early in the summer it is well to level off the mounds remaining from the previous season's treatment. This permits the new generation of borers to enter the tree at the normal location on the trunk, and facilitates the subsequent application of paradichlorobenzene.

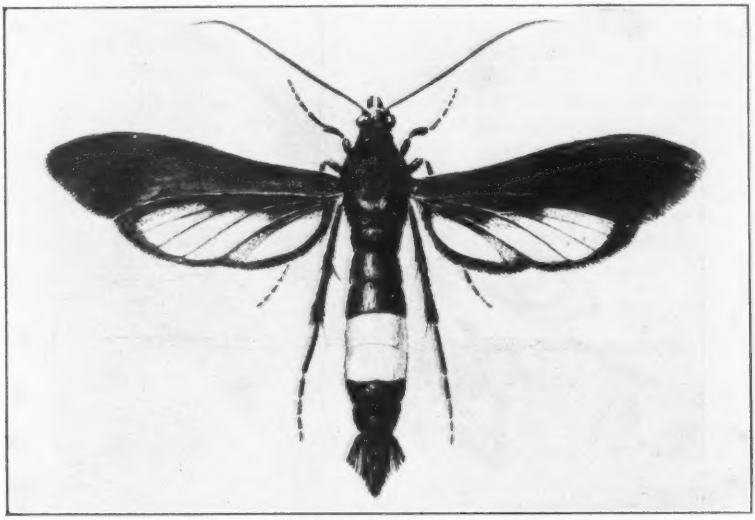

FIGURE 8.—Adult female of the peach borer. Four times natural size.

INJURY

Under certain conditions paradichlorobenzene may cause injury to peach trees. This injury first becomes evident as brown flecks in the bark layers, which may continue into the cambium. In cases of severe injury these flecks converge into spots, forming a continuous layer of sour, brown tissue, which finally dies. Sometimes the injury extends all the way around the trunk and becomes fatal to the tree.

FIGURE 9.—Steps in the correct method of treating trees with paradichlorobenzene: *A*, The soil around this peach tree has been made ready for treatment; *B*, the ring of crystals should be from 1 to 1½ inches from the tree trunk; *C*, several shovelfuls of soil should be placed on top of the ring of crystals and packed lightly with the back of a shovel.

Injury has been particularly serious on trees 1 to 3 years old in the southeastern part of the country. In a few cases this injury has been severe enough to kill the trees. In many peach sections of the Middle West injury to young trees has occurred less frequently, and in that part of the country many commercial growers make a practice of treating young trees. Trees 4 years of age and older have sometimes suffered slight injury, but this has rarely proved serious. The paradichlorobenzene treatment has been found injurious to peach trees in the nursery and is therefore not recommended for nursery stock.

THE ETHYLENE DICHLORIDE TREATMENT

Ethylene dichloride is a colorless liquid with an odor like chloroform. It is heavier than water and vaporizes freely at ordinary temperatures. The vapor is heavier than air and penetrates the soil very readily. The chemical is only very slightly soluble in water, and it burns with difficulty when ignited by a lighted match. When the vapor of ethylene dichloride is inhaled it has an anaesthetic action, although less rapid than that of chloroform. Unless breathed in high concentrations over a protracted period of time no harmful results need be feared in working with this compound. Long-continued contact with ethylene dichloride has been reported to have caused some skin irritation, and due care should be taken by people who have occasion to work with this material for long periods of time.

PREPARING ETHYLENE DICHLORIDE EMULSION

To avoid concentration of the vapor and any prolonged breathing of it, the emulsion should be prepared out of doors or in a well-ventilated room. It is desirable that the air temperature be between 50° and 80° F. Since the compound boils at temperatures below the boiling point of water, heat should not be employed in making the emulsion, and the liquid should be kept away from fire and open-flame lights.

The stock emulsion is prepared from the following ingredients:

	Parts
Potash fish-oil soap	1
Water	8
Ethylene dichloride	9

A good grade of potash fish-oil soap should be used, that is, one without an excess of caustic potash and containing approximately 30 percent of actual soap and 70 percent of water. The soap should first be put into the mixing vessel and the water added slowly while stirring, until the soap is well dissolved. The ethylene dichloride should then be added and emulsified cold by pumping the mixture into another container.

The stock emulsion may also be made by stirring. By this method the soap is first placed in the mixing container and the ethylene dichloride added slowly, a little at a time, with constant stirring. When the soap and ethylene dichloride are thoroughly mixed, the water is added slowly with constant stirring.

XUM

The stock emulsion made by either method contains 50 percent of ethylene dichloride; it is further diluted with water just before it is used, the amount of dilution depending on the age of the tree and the dosage required.

If the stock emulsion breaks down after preparation, as indicated by the presence of a curdled mass or a layer of clear ethylene dichloride on the bottom, and cannot be readily remixed by moderate agitation, the material must be re-emulsified. This is done by pumping the mixture from one container to another or back into the same container, or by starting over again with a small quantity of potash fish-oil soap to which small quantities of the broken emulsion are added slowly at intervals with constant stirring.

Commercially prepared emulsions are available on the market and bear directions for dilution and use on the packages.

DILUTION AND DOSAGE

Table 1 gives the quantity of water to be added to the 50-percent stock emulsion of ethylene dichloride to get 10 gallons of diluted emulsion of the different strengths and the dosages found by experiment to be most satisfactory for use on peach trees of various ages.

TABLE 1.—*Dilution of stock emulsion, strength of diluted emulsion, and quantity applied to trees of different ages*

Age of trees (years)	Quantity of water and of stock emulsion to use to get 10 gallons of diluted emulsion of the proper strength		Strength of the diluted emulsion	Quantity of the diluted emulsion for each tree
	Water	50-per-cent emulsion		
	Gallons	*Gallons*	*Percent*	*Pints*
4 and older	6	4	20	1½
3	7	3	15	1½
2	7	3	15	¾
1	8½	1½	7.5	⅜

Unusually large older trees may require a little more than a half pint of the emulsion.

WHEN AND HOW TO APPLY THE EMULSION

Ethylene dichloride emulsion can be applied for the control of the peach borer any time during the fall or spring, and in the South applications made in warm periods during the winter will give good control. Best results will probably be obtained in the fall soon after the close of the egg-laying period of the peach borer moths, when most of the borers are small. The use of the material in extremely hot weather should be avoided since injury is more likely to occur at high temperatures.

No preparation of the soil before treatment is necessary on loose, level ground. In some cases, however, cupping the soil slightly toward the tree trunk, to prevent the liquid from running off, or loosening the soil around the tree sufficiently to permit the liquid to be readily absorbed will give better results. Any cracks in the ground close to the tree trunk should be filled with soil before treatment, in order to avoid undue concentration of the material on any part of the root system which might result in injury.

FIGURE 10.—Pouring ethylene dichloride emulsion from a short-handled household measuring cup.

The material is applied either by pouring or spraying it on the base of the tree, in such a way that the soil all around the tree and in immediate contact with the trunk will be wet.

A tin household measuring cup holding one-half pint, with marks for one-eighth and one-fourth pint, will be found useful in applying the emulsion (fig. 10). A bucket pump may be employed in applying the ethylene dichloride, and with a little practice the quantity delivered to each tree can be regulated without difficulty. A power sprayer

equipped with a device for regulating the quantity applied may also be used for this purpose.

It is essential that a uniform mixture be obtained, both in the stock material and the fully diluted spray. The operator should examine the emulsions at frequent intervals to be certain that they have not broken down, permitting the ethylene dichloride to form a separate layer at the bottom of the container. Broken-down emulsions should not be applied, as the portion consisting chiefly of ethylene dichloride may cause serious injury.

After the chemical has been applied, several shovelfuls of soil should be placed against the tree to prevent evaporation from the surface. After this the treatment needs no further attention.

WORMING

Before the development of chemical methods for combating the peach borer, growers relied for control chiefly on digging the borers out by hand. This method is still very useful for the control of the borer in small plantings or on single backyard trees or where it is inconvenient to obtain a supply of the chemical. Worming, however, is a very laborious task and, unless carefully done, is not very effective.

In preparation for worming, the earth should be removed from around the crown of the tree to a depth of 4 or 5 inches, or deeper if necessary. With a little experience the worker can readily locate the borers in their burrows and remove them with a knife or other suitable tool. In worming, care should be taken not to cut the sound bark more than necessary, and the cutting should be done vertically. Carelessness in the use of worming tools may result in as much damage to trees as would be caused by the insects. After the trees have been wormed, it is desirable, if practicable, to go over them again a few days later, when the location of any larvae missed during the first examination will usually be indicated by the exuded frass or gum. When the worming has been completed, the earth should be replaced around the trees before freezing weather sets in.

If worming is to be done, it is helpful to mound the trees somewhat during the early part of the summer. This causes the newly hatched borers to attack the tree a little higher than would otherwise be the case, and the task of removing them by hand is somewhat simplified.

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FARMERS' BULLETIN No. 1246
Apr. 1943

THE PEACH BORER

HOW TO PREVENT OR LESSEN ITS RAVAGES

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UNITED STATES DEPARTMENT OF AGRICULTURE 1889

FOR MORE than a century and a half the peach borer, the larva of a beautiful clear-winged moth, has been one of the principal obstacles to successful culture of the peach. It feeds on the soft inner bark at the base of the tree or on the adjacent roots, seriously injurying and frequently killing the tree. This bulletin treats briefly of the insects's life history and habits and discusses the following three methods of control: (1) The application of paradichlorobenzene, which has been successfully used for more than 20 years on older trees, although often causing damage to trees 3 years of age or younger; (2) the more recently developed ethylene dichloride treatment, which is more effective than the use of paradichlorobenzene in cool weather and much less likely to cause injury to younger trees; and (3) the old-time practice of "worming," a method suitable for the destruction of borers if only a few trees are to be treated or if it is inconvenient to obtain a supply of suitable chemicals.

Washington, D. C.

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XUM

THE PEACH BORER[1]—HOW TO PREVENT OR LESSEN ITS RAVAGES

By OLIVER I. SNAPP, *entomologist, Division of Fruit Insect Investigations Bureau of Entomology and Plant Quarantine, Agricultural Research Administration*

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AMONG INSECT PESTS that attack the peach few, if any, are potentially more injurious than the peach borer (*Sanninoidea exitiosa* (Say)).[2] Throughout much of its range of distribution, east of the Rocky Mountains from Canada to Florida, and in certain restricted areas farther west, it causes serious injury and the premature death of many trees wherever treatment is neglected.

The peach borer is a native of the United States and has been reported in horticultural and other literature almost from the time the early settlers introduced the peach into this country. Its original food plants were doubtless the wild cherries and wild plums, and on these it can still be found. It also attacks other stone fruits, such as nectarine, apricot, prune, almond, plum, and a few other closely related fruit trees. It is, however, preeminently injurious to the peach.

CHARACTER OF INJURY

The injury is done by the larva, or borer, which feeds in the trunk principally at or somewhat below the ground level and eats galleries or burrows in the soft bark or cambium at the crown of the trees or along the larger roots (fig. 1). Young trees may soon be completely girdled (see title page), or nearly so, and older trees so injured that their vitality and crop-bearing capacity are greatly reduced. Injured trees are particularly susceptible to attack by bark beetles and are less able to withstand periods of drought.

Infestation by the borer is usually shown by an exudation of jelly-like gum around the crown, more or less mixed with dirt and brown

[1] The common name "peachtree borer" was officially adopted for this insect by the American Association of Economic Entomologists in February 1942 (Jour. Econ. Ent. 35 : 83–101).

[2] Order Lepidoptera, family Aegeriidae.

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pellets—the excrement, or frass, voided by the borers (fig. 2). This exudation of gum is especially evident during damp or rainy weather.

HOW THE INSECT DEVELOPS AND LIVES

In the course of its life the peach borer goes through four distinct stages—the egg; the larva, or borer; the pupa; and the adult, or parent moth. There is only one generation a year. The eggs hatch in the summer and fall, and the young borers at once attack the trees, passing the winter as partly grown larvae in their burrows. In the spring they resume their growth and mature and spin their cocoons at various times during the summer. The moths emerge during the summer and fall, the exact period differing in different localities. Shortly after emerging the moths lay their eggs.

FIGURE 1.—Peach borers in their galleries at the crown of a peach tree.

THE EGG

The eggs of the peach borer are small and inconspicuous, reddish brown, oblong, and measure about one-fiftieth of an inch in length (fig. 3). Most of the eggs are deposited on the trunk of the tree near the base, although some are placed on the limbs and foliage of the peach tree and a few are laid on weeds and trash or on the ground at or near the bases of the trees. Naturally many larvae fail to establish themselves on the trunks of the trees, but this loss is more than offset by the fact that the moths are very prolific. Observations have shown that a single female may lay more than 1,200 eggs, and the average is probably between 500 and 600.

THE LARVA, OR BORER

The egg hatches in about 10 days, and the little larva coming out of it makes its way as rapidly as possible to the collar of the tree, if

not already in that area, and at once begins burrowing into the bark, often entering through a crack or wound. After the larva has gained entrance to the soft bark of the tree it feeds greedily and grows rapidly, and in a few weeks is sufficiently large to do material damage.

The number of larvae which may infest a single tree is often surprising, and it is a matter of wonder that trees heavily infested are not completely killed within a season. The average number of larvae to a tree in orchards differs widely according to the region. In some regions there are only 2 or 3, whereas in others 8 or 10 borers are usually present. In extreme cases 40, 60, and even 90 borers have been found infesting the roots and crowns of individual peach trees 6 or 7 years old.

The hatching period extends over most of the summer and fall—from late June until October, or even later in the extreme South, although most of the hatching is concentrated in a period of a few weeks in midsummer in northern localities and in late summer or fall at southern points. Larvae of different sizes, however, ranging from small to nearly full-grown may be found in the trees at any time during the summer and fall.

Most of the feeding occurs in the fall and spring, but in the South the borers also feed more or less during warm periods in the winter. The mature peach borer larva (fig. 4) is about an inch long and yellowish white and has a dark reddish head.

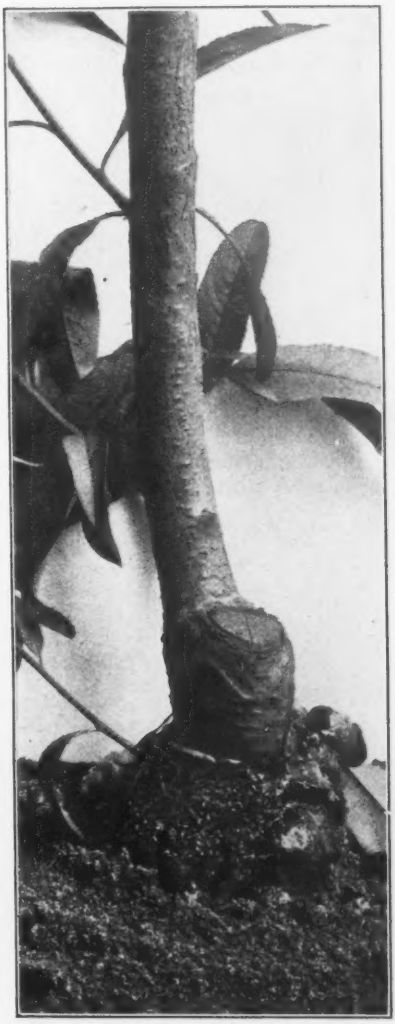

FIGURE 2.—Gum and frass exuding from base of a peach tree, the usual sign of infestation.

THE PUPA

The peach borer, when full-grown and ready to change its form, incloses itself in a cocoon of silk in which are incorporated particles

of bark and excrement, forming a tough, brownish, capsulelike structure. The cocoon (fig. 5) is usually constructed at the entrance to the larval burrow or even a short distance outside it and, because it is similar in color to the bark of the tree, is often overlooked by orchardists. Borers infesting the roots some inches from the base of the tree may work directly upward to the surface of the soil and there construct their cocoons. Sheltered within the cocoon, the larva changes to a pupa, or chrysalis. The pupa (fig. 6) is about three-fourths of an inch long and is brown. On its back are stiff spines that assist it in working itself out of the cocoon and thus facilitate the escape of the moth. Within 3 or 4 weeks the pupa is fully developed and wriggles out. The emerging moth leaves the empty skin protruding more than halfway from the cocoon (fig. 5). Late in the summer large numbers of these empty pupal shells may often be found around the base of a heavily infested tree.

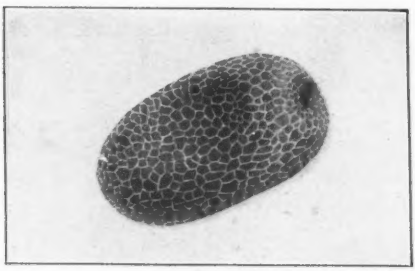

FIGURE 3.—Egg of the peach-borer moth. Sixty times natural size.

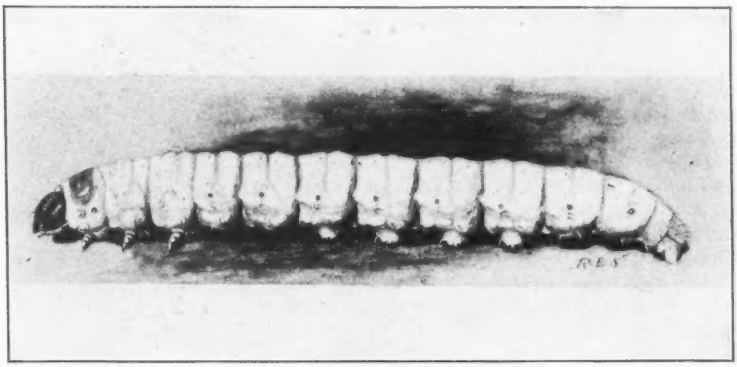

FIGURE 4.—The peach borer. Four times natural size.

THE MOTH

The moths of the peach borer are beautiful, clear-winged insects, the male differing strikingly from the female in markings. The wings of the male (fig. 7) are transparent, with steel-blue trimmings along the margin and veins, and its abdomen is marked with narrow yellow bands conspicuous on the steel-blue ground color. The female (fig. 8) is steel blue, with opaque forewings, and has one or two orange-colored bands around the abdomen.

The adults are day fliers and when on the wing are sometimes mistaken for wasps. Egg laying begins very soon after emergence. It

is doubtful whether the moths feed to any extent, and within a few days the eggs have been deposited, and the moths have died.

HOW TO CONTROL THE PEST

Two very effective insecticides are now available for peach borer control. The first of these, paradichlorobenzene, has been in use for more than 20 years. It is very effective in controlling the borers, but in some localities it is injurious to the younger trees. The second chemical, ethylene dichloride, has been under experiment at the Fort Valley, Ga., laboratory of the Bureau for the last 11 years. It has also been tested extensively in Illinois and New York in cooperation with State workers and has been used by a considerable number of commercial growers in the eastern half of the United States. This treatment has the advantage of being comparatively safe on young trees when applied at the proper strength; it can be used in colder weather than paradichlorobenzene; and it can be applied with greater ease.

FIGURE 5.—The peach borer cocoon and empty pupal skin. Three times natural size.

THE PARADICHLOROBENZENE TREATMENT

Paradichlorobenzene, often referred to as "para" or "PDB", is a white crystalline substance having an etherlike odor and vaporizing readily under favorable conditions. The vapor, while harmless to persons and domestic animals under ordinary conditions, is poisonous to insects confined in its fumes for a sufficient length of time. It is heavier than air and readily permeates the soil. The chemical is, for practical purposes, noninflammable. In purchasing paradichlorobenzene orchardists should demand a grade having the fineness of granulated sugar or one coming in small, thin, flaky crystals. Only the pure chemical should be purchased. Then, if there is some loss by evaporation in the containers, the portion of the chemical that remains is always 100 percent pure. If the chemical is mixed with some inert material the loss by evaporation will be loss of the chemical only, and the strength of the remaining mixture will be unknown.

WHEN TO APPLY IT

Application of paradichlorobenzene to peach trees for the control of the peach borer is most effective in the fall, after most of the moths have laid their eggs. At this time many of the larvae are still small and more or less exposed, and hence are more susceptible to the

gas than if they were deep in their burrows in the crown and roots. Applications must not be delayed, however, until the soil temperature is so low that the chemical will not volatilize properly. Exact information on the best time for treatment in various localities should be obtained from the reader's State agricultural experiment station, extension service, or local authorities. The best approximate dates for certain regions are, however, as follows:

Michigan, New York, and New England States	Aug. 25–Sept. 10.
Southern Lake region, New Jersey, Pennsylvania	Sept. 15–25.
Ozark region, Ohio Valley, Maryland, Virginia, Delaware	Sept. 25–Oct. 5.
Northern Georgia, the Carolinas, Tennessee	Oct. 5–15.
Central Georgia	Oct. 20–25.
Southern Georgia	Oct. 25–30.

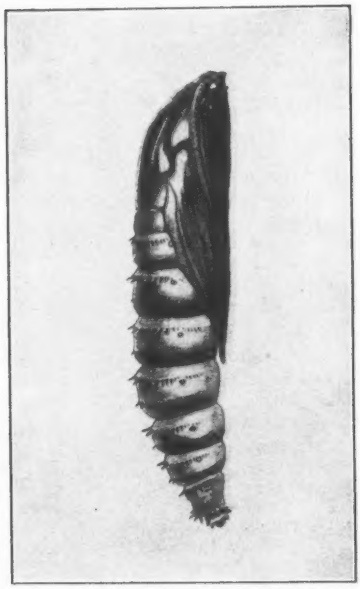

FIGURE 6.—Pupa of the peach borer. Four times natural size.

Fall applications are most effective, but if these have been neglected or were poorly timed, treatment sometimes becomes desirable in the spring. Spring applications of the chemical have given a fairly satisfactory kill, although by that time the borers have of course caused much more damage than would have occurred if they had been killed early in the fall while still small. Spring treatment should be given as soon as the ground begins to warm, the exact time differing with the locality.

PREPARING THE TREES

The earth for 15 or 18 inches around the base of trees should be cleaned of grass and weeds and leveled off, without, however, digging up the soil any more than necessary to break the surface crust (fig. 9, *A*). If borers are in the trunk somewhat above the ground level, as indicated by the presence of gum or frass, a few shovelfuls of earth should be thrown around the tree and leveled off to form a bed on which the chemical will rest above the infested part of the trunk, for this heavy gas sinks rather than rises through the soil. As a rule, raising the soil level around the tree is unnecessary and is undesirable because the mound may be washed down by rain and the effectiveness of the treatment reduced. Excessive gum and frass should be removed. Exposed roots should be covered with a light layer of soil, since they are less resistant to gas fumes than is the bark of the trees.

APPLYING THE CHEMICAL

After the soil has been prepared, the chemical is applied evenly in a band an inch or so wide entirely around the tree, care being taken that the inner part of the band is an inch to an inch and a half from the trunk (fig. 9, *B*). The crystals should not be placed in contact with the tree, since they may injure it, nor should they be placed too far from the tree, in which case not enough gas will reach the tree trunk to be effective. For mature trees of average size 1 ounce, by weight, should be used; for unusually large trees an ounce and a half or more is sometimes needed; for trees 4 to 5 years old, three-

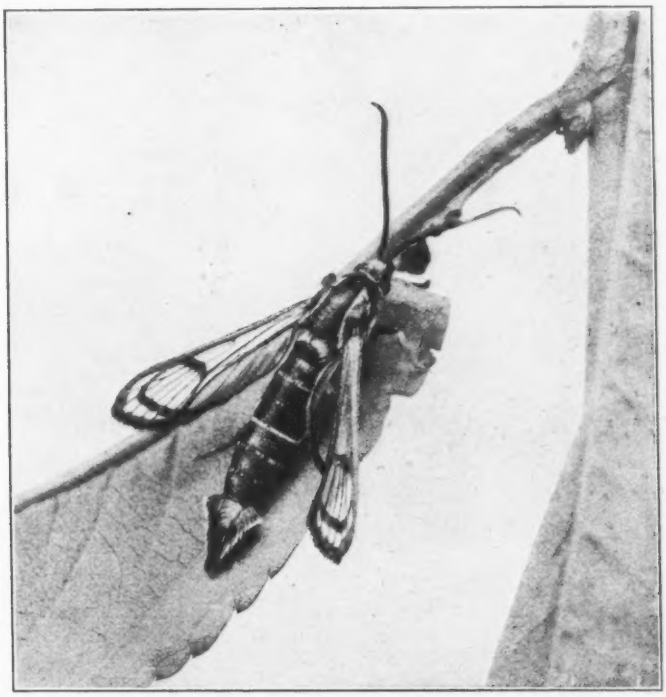

FIGURE 7.—Adult male of the peach borer resting on leaf. Four times natural size.

fourths of an ounce; and if trees 1 to 3 years of age are to be treated, one-fourth to one-half ounce should be used. If many trees are involved, a container holding exactly the required amount of paradichlorobenzene is a great convenience. A small metal cup holding an ounce is often furnished with the chemical by insecticide dealers. As soon as the paradichlorobenzene has been applied, it should be covered with several shovelfuls of dirt, care being taken not to disturb

the ring of crystals, and the dirt packed with the back of the shovel (fig. 9, *C*) to make a low cone-shaped mound.

Under normal temperatures the chemical applied at the recommended dates usually evaporates in 4 to 6 weeks. If unusually low temperatures prevail or if frequent rains keep the soil wet, the evaporation of the chemical may be considerably retarded. Under such conditions, especially on trees less than 6 years of age, it is sometimes desirable to tear down the mounds after from 4 to 6 weeks to prevent the injury which might result from a prolonged exposure to the fumes of the chemical.

If the mounds are torn down late in the fall, just before winter sets in, fresh earth should be placed around the tree to prevent winter injury in event of a sudden drop in temperature.

Late in the spring or early in the summer it is well to level off the mounds remaining from the previous season's treatment. This permits the new generation of borers to enter the tree at the normal location on the trunk, and facilitates the subsequent application of paradichlorobenzene.

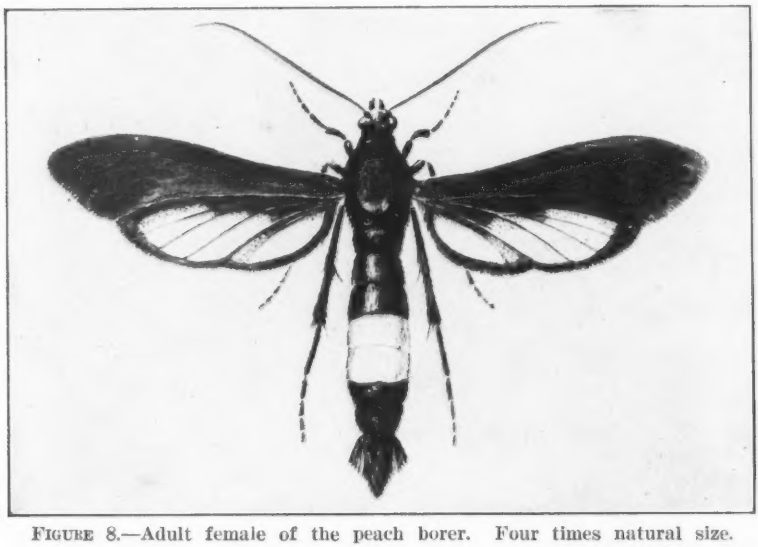

FIGURE 8.—Adult female of the peach borer. Four times natural size.

INJURY

Under certain conditions paradichlorobenzene may cause injury to peach trees. This injury first becomes evident as brown flecks in the bark layers, which may continue into the cambium. In cases of severe injury these flecks converge into spots, forming a continuous layer of brown tissue, which finally dies. Sometimes the injury extends all the way around the trunk and becomes fatal to the tree.

FIGURE 9.—Steps in the correct method of treating trees with paradichlorobenzene: *A*, The soil around this peach tree has been made ready for treatment; *B*, the ring of crystals should be from 1 to 1½ inches from the tree trunk; *C*, several shovelfuls of soil should be placed on top of the ring of crystals and packed lightly with the back of a shovel.

Injury has been particularly serious on trees 1 to 3 years old in the southeastern part of the country. In a few cases this injury has been severe enough to kill the trees. In many peach sections of the Middle West injury to young trees has occurred less frequently, and in that part of the country many commercial growers make a practice of treating young trees. Trees 4 years of age and older have sometimes suffered slight injury, but this has rarely proved serious. The paradichlorobenzene treatment has been found injurious to peach trees in the nursery and is therefore not recommended for nursery stock.

THE ETHYLENE DICHLORIDE TREATMENT

Ethylene dichloride is a colorless liquid with an odor like chloroform. It is heavier than water and vaporizes freely at ordinary temperatures. The vapor is heavier than air and penetrates the soil very readily. The chemical is only very slightly soluble in water, and it burns with difficulty when ignited by a lighted match. When the vapor of ethylene dichloride is inhaled it has an anaesthetic action, although less rapid than that of chloroform. Unless breathed in high concentrations over a protracted period of time no harmful results need be feared in working with this compound. Long-continued contact with ethylene dichloride has been reported to have caused some skin irritation, and due care should be taken by people who have occasion to work with this material for long periods of time.

PREPARING ETHYLENE DICHLORIDE EMULSION

To avoid concentration of the vapor and any prolonged breathing of it, the emulsion should be prepared out of doors or in a well-ventilated room. It is desirable that the air temperature be between 50° and 80° F. Since the compound boils at temperatures below the boiling point of water, heat should not be employed in making the emulsion, and the liquid should be kept away from fire and open-flame lights.

The stock emulsion is prepared from the following ingredients:

	Parts
Potash fish-oil soap	1
Water	8
Ethylene dichloride	9

A good grade of potash fish-oil soap should be used, that is, one without an excess of caustic potash and containing approximately 30 percent of actual soap and 70 percent of water. The soap should first be put into the mixing vessel and the water added slowly while stirring, until the soap is well dissolved. The ethylene dichloride should then be added and emulsified cold by pumping the mixture into another container.

The stock emulsion may also be made by stirring. By this method the soap is first placed in the mixing container and the ethylene dichloride added slowly, a little at a time, with constant stirring. When the soap and ethylene dichloride are thoroughly mixed, the water is added slowly with constant stirring.

XUM

The stock emulsion made by either method contains 50 percent of ethylene dichloride; it is further diluted with water just before it is used, the amount of dilution depending on the age of the tree and the dosage required.

If the stock emulsion breaks down after preparation, as indicated by the presence of a curdled mass or a layer of clear ethylene dichloride on the bottom, and cannot be readily remixed by moderate agitation, the material must be re-emulsified. This is done by pumping the mixture from one container to another or back into the same container, or by starting over again with a small quantity of potash fish-oil soap to which small quantities of the broken emulsion are added slowly at intervals with constant stirring.

Commercially prepared emulsions are available on the market and bear directions for dilution and use on the packages.

DILUTION AND DOSAGE

Table 1 gives the quantity of water to be added to the 50-percent stock emulsion of ethylene dichloride to get 10 gallons of diluted emulsion of the different strengths and the dosages found by experiment to be most satisfactory for use on peach trees of various ages.

TABLE 1.—*Dilution of stock emulsion, strength of diluted emulsion, and quantity applied to trees of different ages*

Age of trees (years)	Quantity of water and of stock emulsion to use to get 10 gallons of diluted emulsion of the proper strength		Strength of the diluted emulsion	Quantity of the diluted emulsion for each tree
	Water	50-per-cent emulsion		
	Gallons	*Gallons*	*Percent*	*Pints*
4 and older	6	4	20	½
3	7	3	15	⅜
2	7	3	15	¾
1	8½	1½	7.5	⅜

Unusually large older trees may require a little more than a half pint of the emulsion.

WHEN AND HOW TO APPLY THE EMULSION

Ethylene dichloride emulsion can be applied for the control of the peach borer any time during the fall or spring, and in the South applications made in warm periods during the winter will give good control. Best results will probably be obtained in the fall soon after the close of the egg-laying period of the peach borer moths, when most of the borers are small. The material should not be applied to waterlogged, heavy soil late in the fall when temperatures are low and should not be used at extremely high temperatures, since it is more likely to cause injury under these conditions.

No preparation of the soil before treatment is necessary on loose, level ground. In some cases, however, cupping the soil slightly toward the tree trunk, to prevent the liquid from running off, or loosening the soil around the tree sufficiently to permit the liquid to be readily absorbed will give better results. Any cracks in the ground around or extending out from the tree trunk should be filled with soil before the treatment is applied in order that undue concentration of the material on any part of the root system, which might result in injury, may be avoided.

FIGURE 10.—Pouring ethylene dichloride emulsion from a short-handled household measuring cup.

The material is applied either by pouring or spraying it on the soil around the base of the tree in such a way that the soil will absorb and hold it around the tree at the ground line. It should not be poured or sprayed on the trunk.

A tin household measuring cup holding one-half pint, with marks for one-eighth and one-fourth pint, will be found useful in applying the emulsion (fig. 10). A bucket pump may be employed in applying the ethylene dichloride, and with a little practice the quantity delivered to each tree can be regulated without difficulty. A power sprayer equipped with a device for regulating the quantity applied may also be used for this purpose.

It is essential that a uniform mixture be obtained, both in the stock material and the fully diluted spray. The stock emulsion should be thoroughly stirred before any is taken from the container for dilution,

and the diluted emulsion should be agitated before each dose is withdrawn for use around the tree. Each bucket of diluted material should be provided with a paddle for agitation if the applications are to be poured on. The operator should examine the emulsions at frequent intervals to be certain that they have not broken down, permitting the ethylene dichloride to form a separate layer at the bottom of the container. Broken-down emulsions should not be applied, as the portion consisting chiefly of ethylene dichloride may cause serious injury.

After the chemical has been applied, several shovelfuls of soil should be placed against the tree to prevent evaporation from the surface. After this the treatment needs no further attention.

INJURY

After the announcement of the ethylene dichloride treatment for peach borer control, a large number of growers in many parts of the country adopted this new method and used it very successfully for the control of the peach borer. Literally hundreds of thousands of peach trees were treated, and for the most part no damage occurred. During 1940, however, the death of considerable numbers of trees and serious injury to others which occurred in the middle Appalachian region were attributed to the use of ethylene dichloride. A careful investigation of the situation revealed that much of the reported injury was actually caused by winter conditions. In many cases there was just as much injury in orchards not receiving the ethylene dichloride treatment as in similar orchards nearby in which the chemical had been used. In a very few cases, however, the emulsion was used at excessive strengths or in other ways not in accordance with recommendations, and some of the injury reported was undoubtedly caused by the chemical.

Further investigations are being carried on by State and Federal workers to determine the conditions under which injury is most likely to occur. These indicate that the margin of safety in the use of ethylene dichloride is narrowest when applications are made to waterlogged, heavy soil late in the fall. It appears that the danger of injury is least in light sandy soils. The investigations have emphasized further the need for strict adherence to the directions for preparing and applying the material outlined in the preceding section.

WORMING

Before the development of chemical methods for combating the peach borer, growers relied for control chiefly on digging the borers out by hand. This method is still very useful for the control of the borer in small plantings or on single backyard trees or where it is inconvenient to obtain a supply of the chemical. Worming, however, is a very laborious task and, unless carefully done, is not very effective.

In preparation for worming, the earth should be removed from around the crown of the tree to a depth of 4 or 5 inches, or deeper if necessary. With a little experience the worker can readily locate the borers in their burrows and remove them with a knife or other suitable tool. In worming, care should be taken not to cut the sound bark more than necessary, and the cutting should be done vertically.

XUM

Carelessness in the use of worming tools may result in as much damage to trees as would be caused by the insects. After the trees have been wormed, it is desirable, if practicable, to go over them again a few days later, when the location of any larvae missed during the first examination will usually be indicated by the exuded frass or gum. When the worming has been completed, the earth should be replaced around the trees before freezing weather sets in.

If worming is to be done, it is helpful to mound the trees somewhat during the early part of the summer. This causes the newly hatched borers to attack the tree a little higher than would otherwise be the case, and the task of removing them by hand is somewhat simplified.

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